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MICROSCOPIC DEMONSTRATION OF COCCI IN THE CENTRAL NERVOUS SYSTEM IN EPIDEMIC POLIOMYELITIS

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After reviewing recent observations on a coccus found in the central nervous system in epidemic poliomyelitis,¹ one of us wrote as follows²:

"To conclude—the exact significance of this coccus in epidemic poliomyelitis cannot be determined now. The number of cases studied for its presence is too small to permit the conclusion that it occurs constantly in the disease or any form of the disease; in the few instances in which injections of culture have resulted in a condition indistinguishable from what is accepted as poliomyelitis in the monkey, the possibility that another and more important microbe may have been present cannot be excluded; the true poliomyelitic nature of the very interesting lesion caused by the coccus in rabbits has not been confirmed by proper tests on monkeys; and we lack also the results of extended immunization experiments. In any event a most interesting coccus has been found that merits study for its own sake as well as on account of the close relation its brief history bears to poliomyelitis."

In order to determine so far as possible whether coccal forms are demonstrable microscopically in the central nervous system in poliomyelitis as it occurs in different places, we obtained from various sources fixed poliomyelitic material, mostly pieces of spinal cord, which we have studied, and we now wish to make a brief report of the results.

On account of the variation in the time after death when the tissues had been fixed as well as on account of the different fixatives employed, uniform results have not been obtained with all the methods of staining that were used. For demonstration of cocci the gram stain was the most satisfactory, but methylene blue and

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¹ Mathers: Jour. Am. Med. Assn., 1916, 67, p. 1019; Jour. Infec. Dis., 1917, 20, p. 113. Rosenow, Towne and Wheeler: Jour. Am. Med. Assn., 1916, 67, p. 1202. Nuzum and Herzog: Ibid., p. 1205; Nuzum, *ibid.*, p. 1437.

² Hektoen: Recent Investigations on the Bacteriology of Acute Poliomyelitis, Boston Med. and Surg. Jour., 1917, 176, p. 687.

TABLE 1
RESULTS OF THE STUDY OF MATERIAL FROM 57 CASES OF EPIDEMIC POLIOMYELITIS

Num- ber	Age	Duration of Illness	Paralysis	Autopsy; Time of after Death	Changes in Cord and Brain	Bacteria in Sections	Source of Material
1	17 mo.	Several days, exact time un- known	No char- acteristic symptoms	17 hours	Marked ganglion cell destruction, round cell infiltration, hyperemia in cord	Medium sized and minute diplo- cocci. Fig. 1	J. H. Wright, Massachusetts General Hospital, Boston
2	5 wk.	Few hours	No char- acteristic symptoms	19 hours	Extreme changes: marked neurophago- cytosis; round cell infiltration and des- tructive changes throughout gray sub- stance of cord	Medium sized cocci and diplo- cocci	J. H. Wright, Massachusetts General Hospital, Boston
3	18 yr.	3 days	Paralysis	28 hours	Marked round cell infiltration, ganglion cell degeneration, hyperemia in cord and stem, round cell perivascular infiltration	Small and medium sized cocci in gray substance of cord	H. E. Robertson, Univ. of Minnesota, Minneapolis
4	35 yr.	6 days	Paralysis	10 hours	Subacute changes, neurophagocytosis and perivascular round cell infiltration being the most striking changes	Very few single cocci and diplo- cocci. Fig. 2	H. E. Robertson, Univ. of Minnesota, Minneapolis
5	11 yr.	4 days	Paralysis	4½ hours	Extreme subacute poliomyelitic changes in cord	Cocci in pairs and short chains; very small and variable in size. Fig. 3	H. E. Robertson, Univ. of Minnesota, Minneapolis
6	3 yr.	11 days	Paralysis	13 hours	Moderate subacute poliomyelitic changes in cord	Cocci in pairs, some large, some small	H. E. Robertson, Univ. of Minnesota, Minneapolis
7	18 yr.	10 days	Paralysis	13 hours	Marked changes in the gray substance of the spinal cord, typical of poliomyelitis	Cocci, single and in pairs, of varying size	H. E. Robertson, Univ. of Minnesota, Minneapolis
8	16 mo.	33 days	Paralysis	About 12 hours	Moderate, subacute changes; small capil- lary hemorrhages especially numerous, diffuse round cell infiltration	A few cocci in pairs, variable in size	D. R. Gurley, Department of Health, New York City
9	2½ yr.	6 days	Paralysis	24 hours	Marked changes, poliomyelitic in nature, especially in upper end of cord	Small cocci in pairs and singly. Fig. 4	D. R. Gurley, Department of Health, New York City
10	7 mo.	7 days	Paralysis	Same day as death	Characteristic changes of poliomyelitis in dorsal cord	Cocci in pairs and singly; not numerous	D. R. Gurley, Department of Health, New York City
11	19 mo.	36 days	Paralysis	Same day as death	Marked poliomyelitic changes in the gray substance of cord	Small cocci in pairs and singly. Fig. 5	D. R. Gurley, Department of Health, New York City
12	32 yr.	5 days	Paralysis	Same day as death	Extreme poliomyelitic changes in the gray substance of cord	Cocci, quite numerous.....	D. R. Gurley, Department of Health, New York City
13	12 mo.	7 days	Paralysis	Day follow- ing death	Infiltration about blood vessels is only noteworthy change	Cocci, variable in size, in pairs and singly	D. R. Gurley, Department of Health, New York City
14	9 yr.	?	Paralysis	2½ hours	No poliomyelitic change.....	No bacteria demonstrable.....	F. B. Mallory, Boston City Hospital, Boston
15	1¼ yr.	?	Paralysis	2 hours	No changes characteristic of poliomyel- itis	No bacteria observed.....	F. B. Mallory, Boston City Hospital, Boston
16	Infant	?	Paralysis	9½ hours	Characteristic changes of poliomyelitis, acute in type; no neurophagocytosis	Cocci in pairs and groups. Fig. 6	F. B. Mallory, Boston City Hospital, Boston
17	10 mo.	?	Paralysis	12 hours	Acute poliomyelitic changes.....	Cocci in pairs and singly, large and small	F. B. Mallory, Boston City Hospital, Boston

18	2 yr.	?	Paralysis	4 hours	Marked acute changes characteristic of poliomyelitis	Cocci in pairs and short chains. Fig. 7	F. B. Mallory, Boston City Hospital, Boston
19	15 yr.	?	Paralysis	12 hours	Perivascular and diffuse infiltration, especially in the anterior horns of cord	Cocci in pairs and singly	F. B. Mallory, Boston City Hospital, Boston
20	1½ yr.	?	Paralysis	17½ hours	Sections do not stain well. Diffuse infiltration of spinal cord and marked perivascular infiltration especially of vessels of anterior fissure	Cocci in pairs and singly. Fig. 8	F. B. Mallory, Boston City Hospital, Boston
21	1½ yr.	?	Paralysis	3 hours	Hemorrhages and cell infiltration.....	Cocci in pairs and singly	F. B. Mallory, Boston City Hospital, Boston
22	1½ yr.	?	Paralysis	8 hours	Marked perivascular changes, and small areas of diffuse infiltration in gray substance of cord; many hemorrhages; neurophagocytosis	Cocci in gray substance of cord. Fig. 9	F. B. Mallory, Boston City Hospital, Boston
23	9 yr.	?	Paralysis	10 hours	Hemorrhages and infiltration.....	Cocci, singly and in pairs	F. B. Mallory, Boston City Hospital, Boston
24	9 yr.	?	Paralysis	50 minutes	Marked diffuse and perivascular infiltration and hemorrhages in gray substance of cord	Cocci, in pairs and singly	F. B. Mallory, Boston City Hospital, Boston
25	? (84 cm.)	?	Paralysis	3½ hours	Marked meningeal changes and extreme infiltration of gray substance of cord	Cocci, small and large.....	F. B. Mallory, Boston City Hospital, Boston
26	3½ yr.	?	Paralysis	45 minutes	Changes pronounced, especially infiltration	Cocci, small and large.....	F. B. Mallory, Boston City Hospital, Boston
27	9 mo.	?	Paralysis	5½ hours	Marked changes, with pial exudate.....	Cocci, in pairs and singly. Fig. 10	F. B. Mallory, Boston City Hospital, Boston
28	3½ yr.	?	Paralysis	55 minutes	Changes in the gray substance of a mild type	Small cocci	F. B. Mallory, Boston City Hospital, Boston
29	25 yr.	?	Paralysis	2½ hours	Marked poliomyelitic changes in cord; pial exudate containing large numbers of leukocytes	Small and large coccus forms..	F. B. Mallory, Boston City Hospital, Boston
30	20 mo.	5 days	Paralysis	Soon after death	Marked infiltration and numerous hemorrhages in gray substance of cord	Small and large forms of cocci. Fig. 11	J. A. Kolmer, Univ. of Pennsylvania, Philadelphia
31	4 yr.	2 days	Paralysis	Soon after death	Moderate infiltration and a few hemorrhages in gray substance of cord	Small and large cocci.....	J. A. Kolmer, Univ. of Pennsylvania, Philadelphia
32	8 yr.	4 days	Paralysis	Soon after death	Patchy infiltration of gray substance as well as perivascular changes	Large and small cocci.....	J. A. Kolmer, Univ. of Pennsylvania, Philadelphia
33	3½ yr.	9 days	Paralysis	Soon after death	Marked diffuse infiltration of gray substance throughout which are scattered denser collections of cells	Large and small cocci.....	J. A. Kolmer, Univ. of Pennsylvania, Philadelphia
34	2 yr.	7 days	Paralysis	4 hours	Extensive changes in the cord and meninges	Large and small cocci. Fig. 12	G. W. McCoy, U. S. Public Health, Washington, D. C.
35	40 da.	4 days	Paralysis	5 hours	Perivascular and diffuse infiltration especially of anterior horn with minute abscesses; satellitosis	Medium sized cocci forms.....	G. W. McCoy, U. S. Public Health, Washington, D. C.
36	2 yr.	8 days	Paralysis	11 hours	Marked infiltration of gray substance of cord	Large and small cocci. Fig. 13	G. W. McCoy, U. S. Public Health, Washington, D. C.
37	11 mo. 2½ yr.	13 days	Paralysis	8 hours	Mild diffuse and perivascular infiltration of gray substance of cord	Diplococci	McKenzie, Presbyterian Hospital, New York City
38	5½ yr.	?	Paralysis right leg and both arms	7 hours	No characteristic changes in spinal cord	No bacteria	McKenzie, Presbyterian Hospital, New York City

TABLE 1—Continued
RESULTS OF THE STUDY OF MATERIAL FROM 57 CASES OF EPIDEMIC POLIOMYELITIS

Num-ber	Age	Duration of Illness	Paralysis	Autopsy: Time of after Death	Changes in Cord and Brain	Bacteria in Sections	Source of Material
39	5 yr.	4 days	Paralysis	78 hours	Moderate acute changes; neurophagocytosis	Cocci, small and large.....	McKenzie, Presbyterian Hospital, New York City
40	2½ yr.	?	Paralysis	30 hours	Hemorrhages and early infiltration.....	Cocci, large and small.....	McKenzie, Presbyterian Hospital, New York City
41	17 mo.	?	Paralysis neck and arms	13 hours	Marked changes; hemorrhages, infiltration and neurophagocytosis in brain and cord	Cocci in cord.....	McKenzie, Presbyterian Hospital, New York City
42	14 mo.	?	Facial paralysis	14 hours	Moderate inflammatory changes in gray substance of cord	Cocci, large and small.....	McKenzie, Presbyterian Hospital, New York City
43	8 yr.	?	Paralysis 9th, 10th and 12th nerves	12 hours	Very slight changes.....	Cocci in gray substance of cord	McKenzie, Presbyterian Hospital, New York City
44	3 yr.	3 days	Paralysis cerebral type	6 hours	Marked perivascular changes in brain and cord; hemorrhages also	Cocci in brain and cord.....	McKenzie, Presbyterian Hospital, New York City
45	9 mo.	?	Paralysis	20 hours	No changes	No bacteria demonstrable.....	McKenzie, Presbyterian Hospital, New York City
46	7 yr.	2 days	Paralysis	18 hours	Hemorrhagic changes predominate.....	Cocci in brain and cord.....	McKenzie, Presbyterian Hospital, New York City
47	5½ yr.	?	Cerebral type	15 hours	Marked infiltrative changes in brain and cord	Cocci in cord.....	McKenzie, Presbyterian Hospital, New York City
48	6 yr.	5 days	Respiratory paralysis	4 hours	Marked changes	Cocci in brain and cord.....	Mathers, Memorial Institute of Infectious Diseases
49	6 yr.	3 days	Respiratory paralysis	12 hours	Marked infiltrative changes in gray substance of cord	Cocci in cord.....	Mathers, Memorial Institute of Infectious Diseases
50	26 yr.	7 days	General paralysis	1 hour	Changes typical of poliomyelitis.....	Cocci in cord and brain.....	Mathers, Memorial Institute of Infectious Diseases
51	24 yr.	5 days	Respiratory paralysis	1 hour	Marked poliomyelitic changes.....	Cocci n brain and cord. Fig. 14	Mathers, Memorial Institute of Infectious Diseases
52	2 yr.	9 days	Extremities paralyzed	2 hours	Extreme infiltrative changes, especially in gray substance of cord	Cocci in brain and cord.....	Mathers, Memorial Institute of Infectious Diseases
53	6 mo.	9 days	Respiratory paralysis	8 hours	Moderate infiltration and hemorrhages in spinal cord	Cocci in brain and cord.....	Mathers, Memorial Institute of Infectious Diseases
54	6 yr.	6 days	Cerebral type	2 hours	Marked infiltrative changes, some satellitosis	Cocci, large and small in cord	Mathers, Memorial Institute of Infectious Diseases
55	14 yr.	5 days	Respiratory paralysis	3 hours	Moderate infiltration, diffuse and perivascular; hemorrhages in gray substance of brain and cord	Cocci, large and small in cord	Mathers, Memorial Institute of Infectious Diseases
56	2 yr.	4 days	Extremities involved	1 hour	Marked infiltration and hemorrhagic changes in cord	Cocci, large and small in cord	Mathers, Memorial Institute of Infectious Diseases
57	Material from epidemic of 1906 in Norway				Extensive poliomyelitic changes in gray substance of cord	Cocci, large and small. Fig. 15	F. Harbitz, Christiania, Norway

eosin and polychrome methylene blue and eosin also proved useful. The pieces were embedded in paraffin; the sections were from 5-10 microns thick.

In all, material from 57 cases has been studied (Table 1). Except in a few instances changes characteristic of epidemic poliomyelitis were present, most markedly in the gray matter, particularly the anterior horns, and in some cases, but to a much less extent, also in the membranes. The changes were hemorrhages, edema, and cellular infiltration, especially about the blood vessels; in most cases the perivascular infiltration was marked, and often associated with more diffuse infiltrations in the gray matter as well as dense focal accumulations of cells. Typical neurophagocytosis and extensive destruction of ganglion cells were present, but not in all the specimens; in a few cases the ganglion cells appeared to have been singled out for attack.

Definite coccal forms were found rather easily in sections showing typical poliomyelitic changes (Table 1 and Plates 1-3). They were single, oftener in pairs, occasionally in small clumps, usually outside but also within cells. They were located in the gray matter, in the walls of the blood vessels, in perivascular and other infiltrates, and in hemorrhagic areas; they were found also in meningeal infiltrations. These cocci correspond in general, so far as shape and size and staining by Gram's method are concerned, with the cocci recently isolated in cultures of the central nervous system in epidemic poliomyelitis. This statement is particularly applicable to Cases 48 to 56, Table 1, in which pure cultures of the coccus in mind were obtained by Mathers¹ from the brain and cord. The cocci in the sections may vary in size, and larger and smaller forms may occur together. We did not find any other microbic forms than those described, and we found no such forms at all in tissues which did not show any changes.

SUMMARY

The cord and other parts of the central nervous system of about 50 instances of epidemic poliomyelitis, occurring in different parts of the country, have been found to contain in stained sections, cocci which look quite like the cocci that may be grown in cultures from the brain and cord in poliomyelitis. This result indicates that such cocci occur constantly in the central nervous system in epidemic poliomyelitis, and that their presence here is not explainable as due to accident or contamination.

PLATES 1, 2, 3

Magnification $1000\times$. For details of the cases see Table 1.

Fig. 1.—Case 1.

Fig. 2.—Case 4.

Fig. 3.—Case 5.

Fig. 4.—Case 9.

Fig. 5.—Case 11.

Fig. 6.—Case 16.

Fig. 7.—Case 18.

Fig. 8.—Case 20.

Fig. 9.—Case 22.

Fig. 10.—Case 27.

Fig. 11.—Case 30.

Fig. 12.—Case 34.

Fig. 13.—Case 36.

Fig. 14.—Case 51.

Fig. 15.—Case 57.

PLATE 1

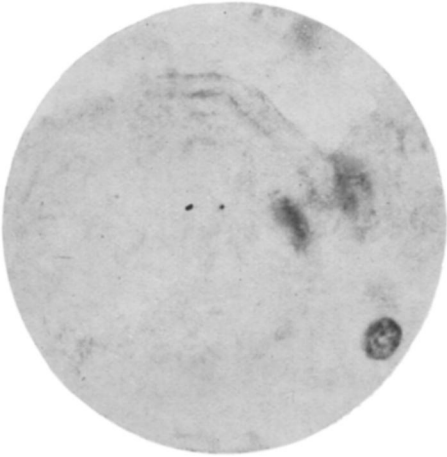


Fig. 1.

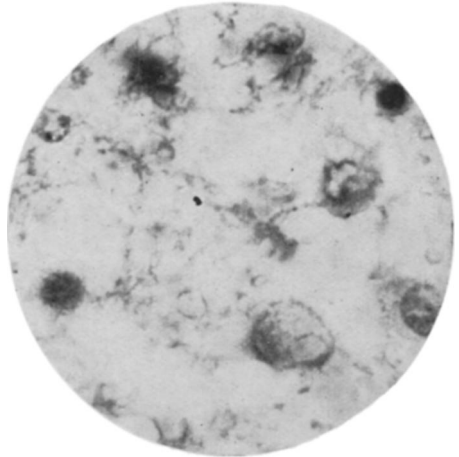


Fig. 2.

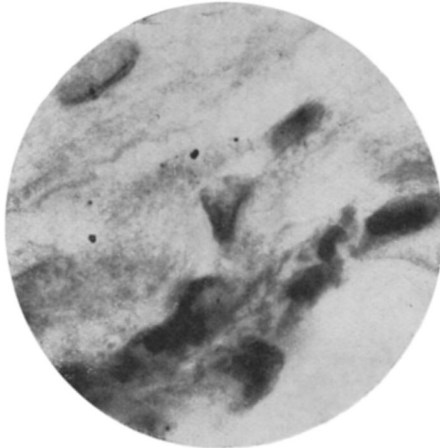


Fig. 3.

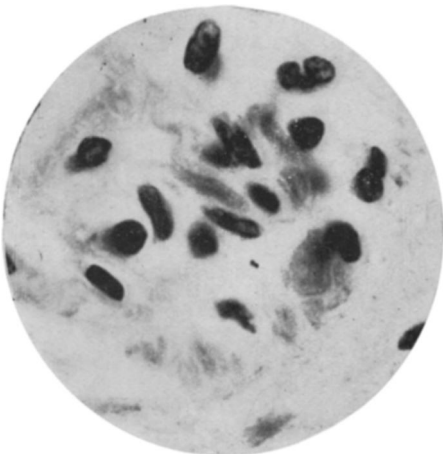


Fig. 4.

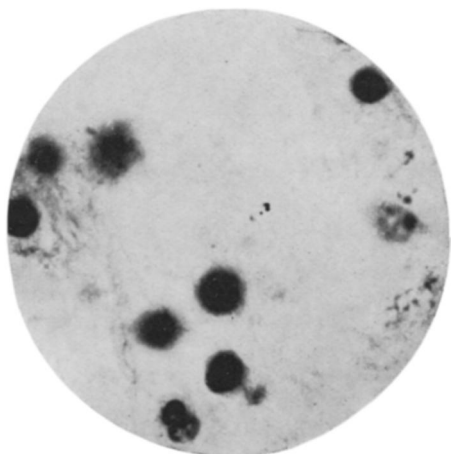


Fig. 5.

PLATE 2

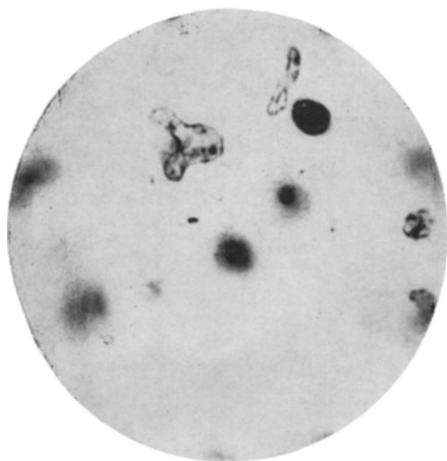


Fig. 6.

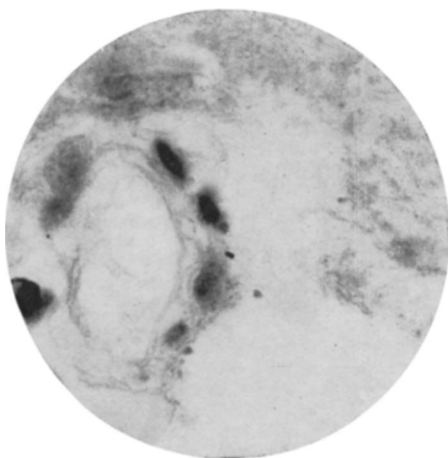


Fig. 7.

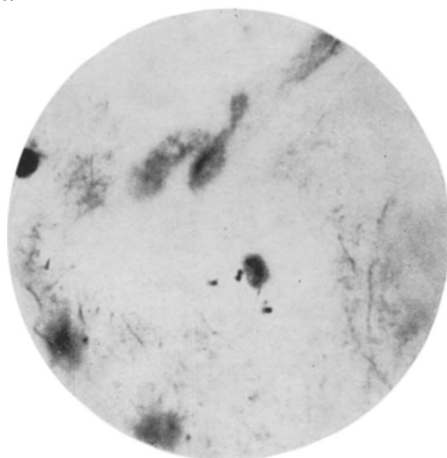


Fig. 8.



Fig. 9.

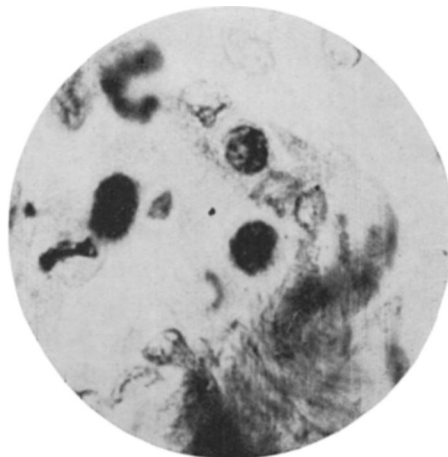


Fig. 10.

PLATE 3

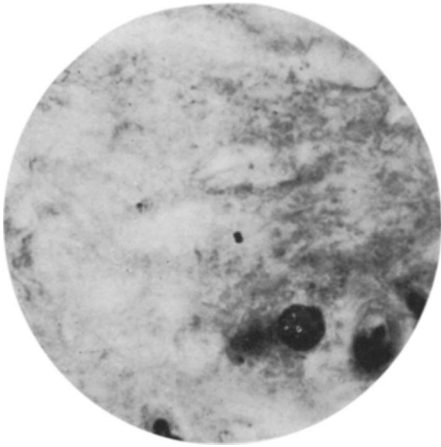


Fig. 11.

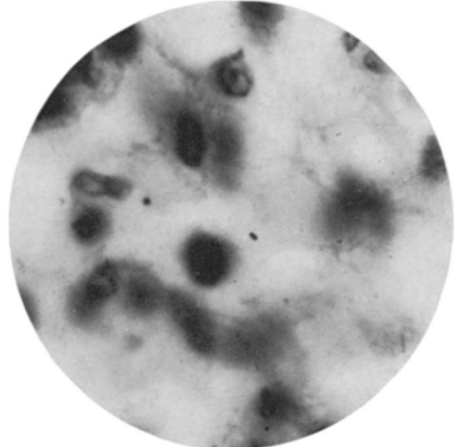


Fig. 12.

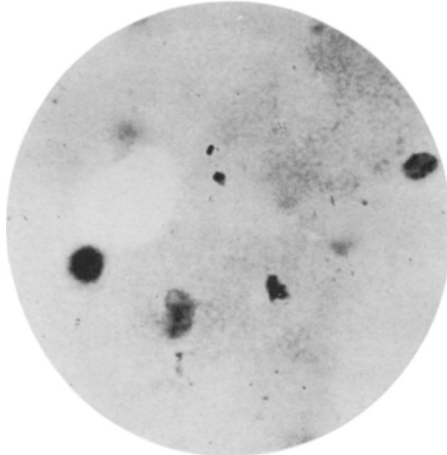


Fig. 13.

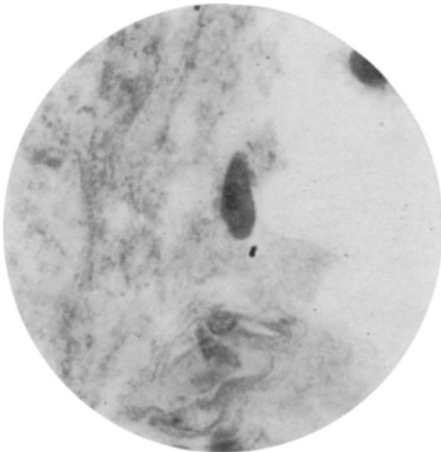


Fig. 14.

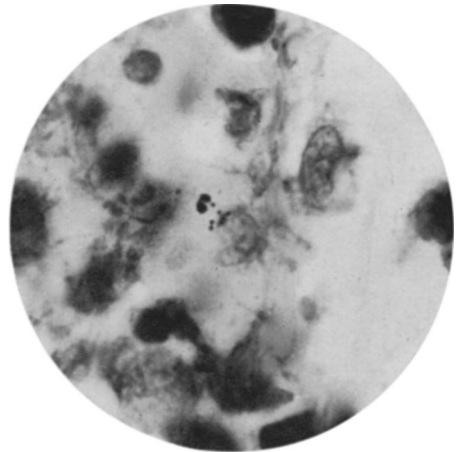


Fig. 15.